



EDSGN100 Design Project #2

Final Design Report

Fitness Band for Adults

Introduction to Engineering Design EDGSN 100 Section 13

Engineering Barbies

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Date: 04/17/2014

Executive Summary

This report details every aspect of the Fitness Band for Adults. Designed for adults over 40 looking to maintain a healthy lifestyle through the tracking of nutrition and exercise, and the monitoring of certain health conditions, the band will have the ability to connect with smartphones and a website using AT&T's Internet of Things and Machine to Machine capabilities. However, what is just as important as the final product is the process by which this band came to be developed. Through research into competitors, available technology, and the targeted audience, certain specifications came to be. Many ideas were tested based on these specs until the very best features were selected. These features are what make this band unique, accessible, and masterfully designed.

Spring 2014

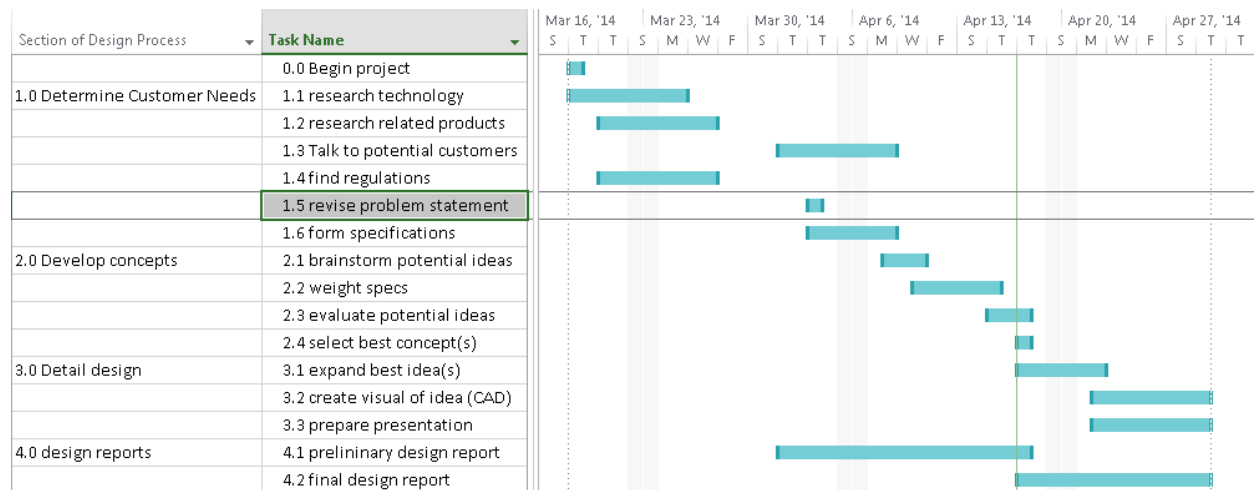
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1.0 Introduction

AT&T, a premier communications holding company, has asked Penn State's Engineering Design 100 classes to "identify opportunities that leverage real-time connectivity and new and emerging technologies to collect information that can be used for products and systems that benefit our lives" in one of the following three categories: connected home, connected car, or wearables. The product must include Machine to Machine and Internet of Things technology. M2M and IoT technology has the ability to connect multiple devices without the need of human interaction. This makes for endless possibilities to improve upon preexisting products or create a completely new device.

The Engineering Barbies decided to design a product in the wearables area, which includes any technology that can be worn, as opposed to carried and held. This includes bracelets, patches, clip-ons, inserts in shoes, watches, and more. After some deliberation, the group decided to improve upon and modify current products, creating something similar to the Nike Fuelband© or FitBit© but targeted at older, active adults.

FIGURE 1. GANTT CHART: A TIMELINE OF PROJECT OBJECTIVES



2.0 Project Background

The Engineering Barbies' problem objective is to "create a wearable bracelet which can incorporate monitoring, planning and tracking of various health concerns (exercise, nutrition, vitals, sleep, etc) for older, active adults." In this age of the obesity

epidemic, it is commonly known how important it is for everyone to be able to track their health. The older generation is the fastest growing population group, and it is important to include them in the technology age in order to encourage them to be interested in tracking and taking more control over their health. The group believes the ease, style, and convenience of a fitness and health centered wearable can be extended to the older generation by simplifying the product and adding features which are more interesting to them, as opposed to young adults' or serious athletes' interests in such a product. In order to learn more about what would be needed to create a successful wearable for older adults, technical research was conducted, as well as interviews with potential customers.

2.1 Technical Research

2.11 IP Address

IP address, or Internet Protocol address, is widely served as a unique identifier for a device that used the TCP or IP protocol. With today's technology, IP addresses are divided into divisions: IPv6 and IPv4. IPv4 addresses are 32 binary bits addresses, expressed by four numbers separated by a dot. Most computers use this type of addresses. IPv6 addresses, on the other hand, are one hundred and twenty-eight binary bits, expressed by eight groups of hexadecimal numbers separated by colons and all zero group is replace by double colon to save space. The newer version of most devices is starting to use IPv6 instead of IPv4 because IPv4 is running out of unique combinations.¹

A device must send out a broadcast message to the network to discover a service provider. Once the provider received the message, it recognizes the unique hardware address of the device and send a message back offering its service to that device. The device will then reply that offer with another message requesting an IP address assignment from the provider. Finally, the provider acknowledges the last message and issues an IP address that does not match any other IP addresses currently active on the network.

2.12 Sensors

Sensors are hardware components of a device that can recognize changes of the object and its surrounding and then send the information to the monitoring system. There are four main types of sensing methods. A wired sensing and wireless communication

set-up's investment cost and ongoing labor is lower than a fully wired system, but its accuracy remains satisfactory.

There are many parts in the accelerator, but two of the most important ones are piezoelectric effect and the capacitance sensor. The piezoelectric effect is the most common form of an accelerometer. It uses a small (microscopic) crystal structure to measure the gravity force. The structures create a voltage from the stress due to the accelerative forces. The accelerometer uses the voltage from the crystals to determine the velocity and orientation. The capacitance accelerometer captures the movements of the microstructures due to the accelerative force and translate them into voltage for interpretation.²

Different components of the accelerometer can be purchased separately. Most accelerometers made up of multiple axes. Two axes are used to measure movements in two-dimensions. Three axes captures 3D positioning. Most smart phones uses three axis accelerometers, which are very sensitive. The higher sensitivity the device has, the easier the acceleration can be measured.

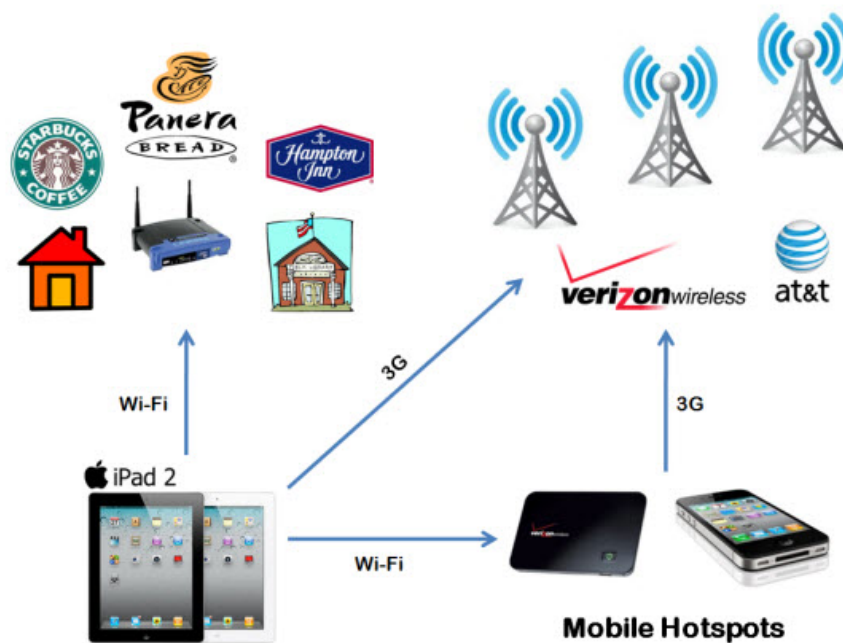
2.13 Communication

Working with different forms of communication is important for devices interacting with each other and how to make human use of these devices as simple as possible. It was necessary to decide which types of communication would potentially be the best way to get wearables to communicate with each other, phones, and computers. The first type of communication researched was Bluetooth technology. Bluetooth is a very useful way to get up to eight devices to communicate with each other as long as they are within 10m of each other and programed to connect with each other. Bluetooth has many advantages because it uses very little battery power and does not require a direct line of sight to send its low frequency radio waves.³

Wi-Fi was the next form of communication researched, also on HowStuffWorks.com. Wi-Fi is a wireless network that also uses radio waves. Unlike Bluetooth, it can come in higher frequencies to transmit more data. Although it requires the connection of a router, the data can also be accessed by more devices and has a greater range of 100 feet.⁴

Mobile broadband was the last form of communication that was researched. Starting at cell towers, signals are sent out through air interfaces using radio waves. The newest type of mobile broadband is 4G LTE, which has a very high capacity for transmitting information. LTE, or long term evolution, is a network that is a protocol that devices use to communicate with base stations. Since it can evolve, this means that this type of communication has great potential for longevity and the ability to transfer and carry more information over time.⁵

FIGURE 2. COMMUNICATION BREAKUP BY TYPE



<http://cdn.noobie.com/wp-content/uploads/2012/10/3g-wifi-diagram.jpg>

2.14 Competitors

A very important aspect of designing this band is knowing what else is on the market. This is useful information because not only does it keep this product from being just like something else already being sold, but it allows it to utilize and incorporate cutting edge technology to put forth an even better product.

The competitors with a similar product to the band include the Nike+ Fuelband and the FitBit Flex. The Nike band's main purpose is to track the intensity of a workout.

Bluetooth syncs this data to the user's phone and allows further tracking through the app. Other notable features include its four day battery life, range of colors and sizes, and \$149-169 price tag. 65% of its users would recommend it. The target group to use this band is people who are already in fairly good shape. Though anyone can use it, it is designed mostly for athletes who have more intense workouts.⁶

The FitBit Flex serves a similar purpose to the Nike band. However, instead of being mainly focused on tracking workouts, this band gives a more holistic picture of health. Its features include a food and workout log to help get a better look into the user's health. Like the Nike band, the FitBit has an app and website that automatically connect to the band through Bluetooth to transfer information hands free. Its battery life ranges from four to five days and the cost is \$99.95. The main differences between these bands are the fact that the FitBit is a more accessible product for the everyday person. Its focus is more on tracking the exercise the user does all day by just walking around with its pedometer and distance tracker. However, it also tracks workouts and food to help track holistic health.⁷

The product research for the band in development went farther than just other bands. The Calorie Counter and Diet Tracker by MyFitnessPal also contributed to the research. The purpose of this app is to log foods and track calories burned working out and gained eating. This data is synced to either their website or app. This app received four out of five stars and is free on the Apple App Store. A pro of this app is that it requires no other hardware to work, unlike a band. However, it requires tedious logging of everything, unlike the band that could track and sync it for the user. This app is mostly useful to those looking to lose a couple of pounds or to make a conscious effort to maintain a goal weight so it has a very wide reaching target demographic.⁸

These three products are very similar to the product in development. However, this research also looked into other less popular products that could possibly be used in accordance with the band and app. The first of these products is the Moticon Sensor Insole. This product is fairly new is therefore only available by request. Pricing information could not be found for this reason. This is an insole that could be put into any shoe. It has a very specific purpose and that is to monitor health by getting an in depth picture of what the user's feet experience. According to its website, it has target audience can be anyone. It claims, "If it is about an impact analysis after leg surgery or

the optimization of the motion sequence of a professional athlete Moticon's novel sensor insole is your every-day solution to measure distribution of pressure, acceleration and motion sequences, thanks to its flexibility and its thin structure. Even the approximate temperature of the foot can be measured.” This is especially useful for someone looking for a very detailed report on their health from a fitness standpoint.⁹ Another product new to the market is AIQ Smart Clothing. This product uses wearable textile electrodes to monitor vitals. Made of conductive yarn, the materials are machine washable and still Bluetooth compatible. It is perfect for the “continuous remote monitoring of health conditions.” If used with a band, these products could wirelessly give a detailed look into the user’s holistic health.¹⁰

2.15 Materials

Thermoplastic Elastomer or TPE has similar properties to rubber. It is recyclable, non-marking and flexible. It comes in clear and opaque. Some of its advantageous characteristics are excellent flexural fatigue resistance, good tear and abrasion resistance, high impact strength, resistance to extreme temperatures, colourability, and resistance to chemical and weathering. In today’s market, TPE is about \$2.30 per kilogram.¹¹

Polyolefin Plastomers, known as POP, is most commonly known as a low-cost sealant. One of its greatest advantages is that it is extremely tough and damage-resistant. It comes in a clear, glossy color, but can also be opaque. Although they are very tough, they provide a high level of flexibility and elasticity.¹²

2.2 Customer Interviews

To get a better understanding of customer needs, nine in-depth interviews were conducted. This was done so specifications could be adjusted according to the needs of customers within our age range, which is active adults ages 40 and up. The ages of those interviewed ranged from ages 47 to 83 and included both male and female participants. All the adults interviewed were at least mildly active and provided information needed to modify the specifications while keeping the customer in mind.

Through the conducted in-depth interviews, it was found that not only do a majority of the interviewees believe that exercise is an important part of life, five out of eight even said that they exercise more than four times a week, and others stated that they

find it difficult to make time to exercise. Although there were mixed reviews about the importance of exercising, all of those interviewed believed that eating healthy is crucial.

Those interviewed were also asked what they would be willing to spend on a wearable bracelet that monitors fitness. A majority said that they would be willing to spend approximately \$100 on such a product, although most were unfamiliar with products such as the Nike Fuelband and FitBit.

The interviewees were also questioned about their health concerns. Conditions mentioned the most were: cholesterol, blood pressure or heart condition, and weight. Most of those interviewed said they would be comfortable having their conditions monitored by a device.

Finally, those interviewed were asked some questions about technology. All of those interviewed said they have access to a computer and/or the internet, while only half of them owned smartphones. When asked what features were most important for a potential wearable device or piece of technology, the most popular were: cameras, GPS, the ability to connect the information to a doctor, and most commonly recommended was the ability to record pulse and pace.

FIGURE 3. TRANSLATION OF CUSTOMER NEEDS TO FEATURES

Customer Need	Number of Customers	Resulting Feature	Level of Importance
Pulse/Pace	7	Pulse/ Pace tracker	1
Connection to a website	9	Website	1
Camera	4	Camera	1
Medication Reminder	1	Screen	1
Sleep Monitor	1	Screen	1
Connection to a smartphone	5	App	2
Connection to a doctor	2	Ability to connect to a doctor through website	2
Time	1	Watch on Screen	3
Calorie Counter/ Nutrition	1	Available through website	3
Blood Sugar	1	Did not pass	—
GPS	4	Did not pass	—

FIGURE 4. TRANSLATION OF SPECIFICATIONS TO FEATURES

Specification to be Satisfied	Resulting Feature	Level of Importance
Adjustable	Expandable	1
Durable/Easy to Clean	TPE	1
Durable/Easy to Clean	POP	1
Affordable	\$100 price	2

3.0 Project Objectives

After research was conducted, a list of specifications were made. These are the most important features of the band that were agreed upon and must be included in the manufacture of the band. Technological specs include sensors, an accelerometer, Bluetooth, Wifi, and 4G compatibility all with a reasonable battery life.

Sensors are important because they give the band the capability to connect to systems

around and send information. This would make it so information on the band could be synced across multiple devices.

The accelerometer was required because having it allows the band to act as a pedometer and to measure the customer's physical activity throughout the day. An accelerometer measures the customer's activities by capturing all the movement both static and dynamic through an electromechanical device. This device measures the amount of acceleration force due to gravity. The force could be static like a gravity pull on your feet while you are standing or dynamic force which will cause the device to move or vibrate. An accelerometer will be a great component for the product because of its ability to measure physical activities.¹³

Through researching different ways of communication, it has been decided that the potential wearable device will need to have Bluetooth capabilities. This way it can access communication with both phones and computers to make transferring data effortless. If said device contains a screen, it can potentially use features such as Wi-Fi and 4G for the technology capable users of the wearable. Being an AT&T product, it could easily integrate AT&T's 4G network to make the band able to sync data at any location, regardless of its physical distance or if there is a Wi-Fi network to connect with. This enables the customer to be constantly updating and getting a better picture of their health.

The wearable device will be using dynamic IPv6 addresses, which can be assigned through Dynamic Host Configuration Protocol. The use of IPv6 was decided on because it will be easier for the customers to acquire the IP address and connected to the server on the go.

A lithium battery with a three day lifespan is a standard across these types of bands. While they range from about three to five days, having a screen on this band would put its lifespan on the lower end of that range. The battery would be rechargeable so the user just needs to plug it in a couple times a week and it will be ready for the next couple of days.

Another feature that is necessary to compete with other bands is having a customizable band. This means it must come in different colors and, more importantly, different sizes. This will make the band fit everyone perfectly.

It is also important that the band is very durable. This means the band can handle years of constant use without breaking or not performing its necessary tasks. It must be able to survive the occasional drop or whatever else comes its way.

Because it will be worn so often, it must be easy to clean. Just like its user, who will need a shower every day or after a workout, the band will need the same. Cleaning the band should be as effortless as everything else with the band and should not damage it.

After talking to the customers, more specifications were brought to the forefront. These next specs were created to best fit their needs. The customers were keen on having the capability to monitor their nutrition and exercise. To fully make this possible would require an internet component. The band would collect and send information and the user could manage and view it on the website in depth. They could track their workouts from the day as well as foods they ate and the calories and nutrients in those foods using nothing but their band and its website. Having it compatible with smartphones is also useful, but would not be as highly utilized based on the resources available to the targeted user.

Other important specifications include having a camera, GPS, the ability to connect the information to a doctor, and especially the ability to record pulse and pace. To record pulse, a Pulse Sensor will be used. Pulse Sensor is an open source sensor. It can measure the user's heartbeat precisely, through their skin. It is very low cost for its ability. It has a size of a button, which makes it very easy to insert the Pulse Sensor into the band. It will record heart rate throughout the day and then be viewable on the website or app.¹⁴

Also, the band will have a price of around \$100. This is the value it has based on interviews and research into its competitors.

FIGURE 5. PIECEWISE SPECIFICATION MATRIX

Specification	sizes/colors	durable	clean	exercise	nutrition	affordable	<40 grams	pleasing	
multiple sizes/colors	x	2	2	4	4	3	1	1	
durable	0.5	x	1	2	2	1	0.5	0.3	
easy to clean	0.5	1	x	3	3	1	0.5	1	
exercise monitor	0.25	0.5	0.3	x	1	0.3	0.3	0.25	
nutrition monitor	0.25	0.5	0.3	1	x	0.3	0.3	0.25	
affordable (\$50-100 total)	0.3	1	1	3	3	x	0.5	0.3	
<40 grams	1	2	2	3	3	2	x	0.3	
astetically pleasing	1	3	1	4	4	3	3	x	
	3.8	10	7.6	20	20	10.6	6.1	3.4	81.5
	0.046626	0.1227	0.0933	0.2454	0.2454	0.13006	0.0748	0.04172	1
	5%	12%	9%	25%	25%	13%	7%	4%	100%

4.0 Conceptual Designs

Many ideas were considered at this point of the design process. However, many aspects of the product such as the materials, sensors, and methods of communication needed to be further researched so that it can have the best design possible. After gathering all of the necessary information, all of the ideas were analyzed. They were compared to the specifications and ranked according to their qualification and importance to the overall quality of the product. Once this process is completed, the product's final conceptual design is invented.

4.1 Descriptions

Many ideas for the product are brainstormed so much so that its possibilities seem endless. The following is the list of the ideas and their descriptions:

- Screen: For time, stopwatch, exercise and calorie monitoring, and overall aesthetic
- Camera: use as a scanner for the calorie counting using barcodes and QR codes
- GPS: keep track of where ever the exercise takes place and also help improve accuracy of the overall distance
- Clock/Stop Watch/Timer: making every exercise easier to keep track off
- Blood Pressure: keep track of customer's blood pressure whenever and wherever he/she goes
- Sleep Monitor: monitor customer's quality and quantity of sleep through their heart rate

- Pulse Sensor: monitor customer's heart rate throughout the day
- Calorie Counter: keep track of customer's calorie on the web with a secured account or do it on the go with an app. With the online account, he/she can track his/her nutrition such as protein and carbohydrate intake in more detail
- Nutrition Suggestions: another helpful feature of the website give suggestions whenever customer's not reach his/her daily goal, physically and nutritionally
- MedReminder: the customer can set an alarm to whenever he/she need to take his/her daily medication(s)
- Results sent to one's physicians of choice: since the customers are already keeping track their daily activities and food intake, they can make their next doctor visit a lot smoother by allowing their doctor to view their progress through the website so the doctors get a better look and recommends treatment and medication more accurately
- Ability to expand up to 1 inch: everyone is unique, the group wants our product to fit everyone
- EPR: durable, tear and abrasion resilient material has many uses because of its varied production techniques¹⁵
- Gore-tex: bi-component membrane makes material water and windproof without sacrificing its breathability¹⁶
- TPE: lightweight, low cost, flexible, durable, and easy to clean, Thermoplastic elastomer can be used as the main component of the band.
- POP: cost-efficient, flexible, and durable sealant that can be used as the outer shell of the band

4.2 Concept Selection

Once the specifications were determined for the guidelines of the design, they were used to compare the different potential features that were brainstormed for the wearable product. A first concept screening chart, seen below, was made to determine if each possible idea would help or hinder the specifications. This was done so it could be determined which features met the most specifications. The potential features with the most pluses, or met the most requirements that were determined through the preliminary research, were the features that would move on to the next round of screening. After this first round of screening it was decided that features such as a GPS, blood pressure monitor, barcode scanner, and a patch to more closely record health conditions would be too costly and were unnecessary for the overall product.

This screening also helped to narrow down the choices for a potential material for the wearable to either TPE or POP.

FIGURE 6. SPECIFICATIONS VS. SPECIFICATIONS MATRIX

Specification/Idea	screen	camera	GPS	barcode scanner	clock/watch	patch	blood pressure	sleep monitor	calorie counting	nutrition tracking	connect to doc	expandable 1in	EPR	gore-tex	TPE	POP
multiple sizes/colors	0	0	0	0	0	0	0	0	0	0	0	/+	/+	/+	/+	/+
durable	0	0	0	0	0	0	0	0	0	0	0	-	/+	-	/+	-
easy to clean	0	0	0	0	0	0	0	0	0	0	0	-	-	/+	/+	/+
exercise monitor	/+	-	/+	-	/+	/+	-	-	/+	-	/+	0	0	0	0	0
nutrition monitor	/+	/+	-	/+	-	-	-	-	/+	/+	/+	0	0	0	0	0
affordable (\$50-100 total)	-	/+	-	/+	/+	/+	-	/+	/+	/+	/+	/+	-	-	/+	/+
<40 grams	-	/+	-	/+	/+	/+	-	/+	/+	0	0	-	-	/+	/+	/+
astetically pleasing	/+	/+	-	/+	/+	-	/+	/+	0	0	0	/+	-	/+	/+	/+
plus	3	4	1	4	4	3	1	3	4	2	3	3	2	4	6	5
zero	3	3	3	3	3	3	3	3	4	5	5	2	2	2	2	2
minus	2	1	4	1	1	2	4	2	0	1	0	3	3	2	0	1
net	1	3	-3	3	3	1	-3	1	4	1	3	0	-1	2	6	4
move on?	yes	yes	no	no	yes	no	no	yes	yes	yes	yes	yes	no	no	yes	yes

Next, the different specifications were weighed against each other. This was done to determine which specifications were most important to focus on when looking to see what product feature ideas met which specifications. Through weighing the specifications, it was decided that it would be most important for the device to track nutrition and track exercise, while there will be less focus on whether the product is aesthetically pleasing and if it comes in a variety of colors and sizes. This is the chart which allowed the group to determine the most important specifications.

Lastly the concepts that made it through the first screening were scored against the weighted specifications. This process decided which of the brainstormed ideas met the important specifications and which ones did not. This process involved combining the percentages from the weighing specifications chart and comparing these percentages with a rating. This rating was where the ideas were ranked on a scale of zero to five on how well they met each of the specifications. Through this combined scoring process, the features that met the most specifications easily stood out.

FIGURE 7. WEIGHTED CONCEPT SCORING

Selection Criteria	Weight	screen		Camera		watch		sleep monitor		calorie counting		nutrition		connect to doctor		expandable		TPE		POP	
		rating	weighted score																		
sizes/color	5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0.2	4	0.2	4	0.2
durable	12%	1	0.12	1	0.12	0	0	0	0	0	0	0	0	0	0	1	0.12	4	0.48	3	0.36
easy to clean	9%	4	0.36	2	0.18	0	0	0	0	0	0	0	0	0	0	1	0.09	4	0.36	3	0.27
exercise	25%	4	1	0	0	4	1	0	0	3	0.75	1	0.25	4	1	0	0	0	0	0	0
nutrition	25%	4	1	3	0.75	2	0.5	0	0	4	1	4	1	4	1	0	0	0	0	0	0
affordable	13%	2	0.26	3	0.39	3	0.39	2	0.26	4	0.52	3	0.39	5	0.65	2	0.26	4	0.52	4	0.52
<40 grams	7%	2	0.14	3	0.21	4	0.28	3	0.21	4	0.28	4	0.28	1	0.07	3	0.21	4	0.28	4	0.28
aesthetics	4%	3	0.12	3	0.12	4	0.16	1	0.04	0	0	0	0	0	0	1	0.04	0	0	0	0

Once all the screening, ranking, and scoring was completed, it was decided what features would become a part of final product so a prototype could be developed. These features included the wearable having a screen, the ability for it to act as a watch, and also a sleep monitor. A camera would be included so the wearable can scan labels for an easy way to keep track of calories. Along with tracking calories, the wearable will be able to keep track of nutrition in general, so users can know if they are sticking to a balanced diet. The fitness bracelet being designed will also be expandable to accommodate different wrist sizes and will be made using either TPE or POP. It will also have the ability to connect the user's information to doctors. The bracelet will feature both Bluetooth and Wi-Fi capabilities to connect this information to not only a phone app, but also a website. The bracelets will also be capable of connecting to mobile broadband. All these features meet the customer needs and the specifications determined through our research and screening.

5.0 Systems Diagram



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